

WHAT IS CLAIMED IS:

1. A method of manufacturing a semiconductor device comprising the steps of:

5 (a) forming a capacitor electrode metal film mainly made of one of Pt and Ir on an underlying layer;

(b) forming a first mask film mainly made of one of Ru and Os on said capacitor electrode metal film;

(c) selectively opening said first mask film;

10 (d) exposing an uncovered part of said capacitor electrode metal film at an opening of said first mask film to a predetermined gas atmosphere so as to volatilize while heating said capacitor electrode metal film, thereby selectively etching said capacitor electrode metal film; and

(e) removing said first mask film.

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2. The method according to claim 1, wherein

said capacitor electrode metal film is a lower electrode metal film of a capacitor,

said method further comprising the steps of:

20 (f) after said step (e), forming a dielectric film covering said lower electrode metal film; and

(g) forming, on said dielectric film, an upper electrode insulated from said lower electrode metal film by said dielectric film.

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3. The method according to claim 2, wherein

a conductive plug is formed in said underlying layer and a first metal film is formed on said underlying layer to be in contact with said conductive plug, and

in said step (a), said lower electrode metal film is formed to be connected to said conductive plug with said first metal film interposed therebetween.

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4. The method according to claim 3, wherein

a second metal film is further formed on said first metal film, said second metal film containing at least one material selected from the group consisting of metal oxide, metal nitride, metal silicide, metal oxynitride, metal silicon-oxide, metal
10 silicon-oxynitride and metal silicon-nitride, and

in said step (a), said lower electrode metal film is formed to be connected to said first metal film with said second metal film interposed therebetween.

5. The method according to claim 3, further comprising the step of

15 (h) in advance of said step (f), forming a contact-preventing metal film preventing contact between said dielectric film and said first metal film.

6. The method according to claim 1, further comprising the step of

(i) in advance of said step (b), forming a first metal film on said capacitor
20 electrode metal film, said first metal film containing at least one material selected from the group consisting of metal oxide, metal nitride, metal silicide, metal oxynitride, metal silicon-oxide, metal silicon-oxynitride and metal silicon-nitride, and

in said step (b), said first mask film is formed on said capacitor electrode metal film with said first metal film therebetween.

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7. The method according to claim 1, wherein

said step (c) includes the steps of:

(c-1) forming a second mask film containing at least one of silicon oxide and silicon nitride on said first mask film;

5 (c-2) patterning said second mask film by photolithography and etching; and

(c-3) selectively etching said first mask film using said second mask film as an etching mask, thereby selectively opening said first mask film.

8. The method according to claim 7, wherein

10 said step (c) further includes the step of

(c-4) in advance of said step (c-1), forming a first metal film on said first mask film, said first metal film containing at least one material selected from the group consisting of metal oxide, metal nitride, metal silicide, metal oxynitride, metal silicon-oxide, metal silicon-oxynitride and metal silicon-nitride, and

15 in said step (c-1), said second mask film is formed on said first mask film with said first metal film therebetween.

9. The method according to claim 7, wherein

20 in said step (c-2), said second mask film as patterned is subjected to isotropic etching.

10. The method according to claim 1, further comprising the step of

(j) after said step (c), performing isotropic etching on said first mask film.

25 11. The method according to claim 1, wherein

an etching stopper film mainly made of one of Ru and Os is formed on said underlying layer,

in said step (a), said capacitor electrode metal film is formed on said etching stopper film, and

5 in said step (d), said etching stopper film is used as an etching stopper in etching said capacitor electrode metal film.

12. The method according to claim 11, wherein

a first metal film is formed on said etching stopper film, said first metal film
10 containing at least one material selected from the group consisting of metal oxide, metal nitride, metal silicide, metal oxynitride, metal silicon-oxide, metal silicon-oxynitride and metal silicon-nitride, and

said capacitor electrode metal film is formed on said etching stopper film with said first metal film therebetween.

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13. The method according to claim 11, wherein

said capacitor electrode metal film is a lower electrode metal film of a capacitor,

said method further comprising the steps of:

20 (f) after said step (e), forming a dielectric film covering said lower electrode metal film;

(g) forming, on said dielectric film, an upper electrode insulated from said lower electrode metal film by said dielectric film; and

(k) in advance of said step (f), forming a contact-preventing metal film
25 preventing contact between said dielectric film and said etching stopper film.

14. The method according to claim 2, wherein

said step (g) includes the steps of:

(g-1) forming, on said dielectric film, an upper electrode metal film insulated
5 from said lower electrode metal film by said dielectric film;

(g-2) forming a third mask film mainly made of one of Ru and Os on said upper
electrode metal film;

(g-3) selectively opening said third mask film; and

(g-4) exposing an uncovered part of said upper electrode metal film at an
10 opening of said third mask film to a predetermined gas atmosphere so as to volatilize
while heating said upper electrode metal film, thereby selectively etching said upper
electrode metal film.